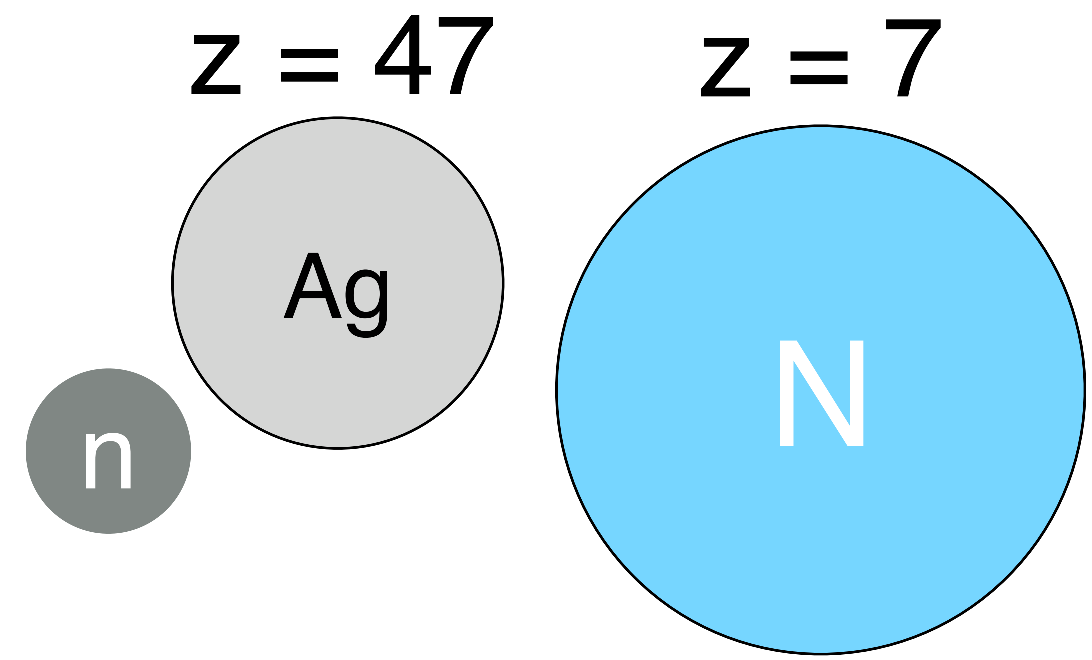
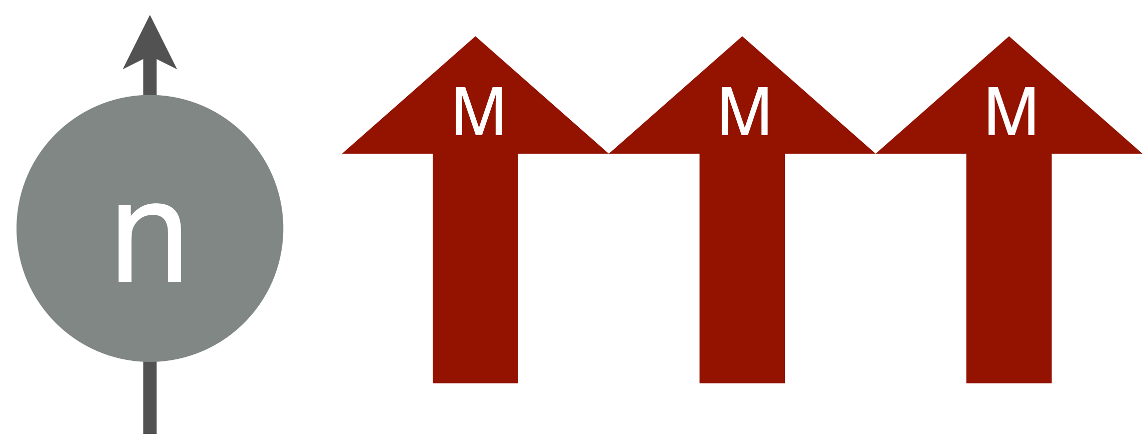
# neutron diffraction

**neutrons are:**

- proper λ for diffraction
- highly penetrating
- see nuclear contrast
- magnetic



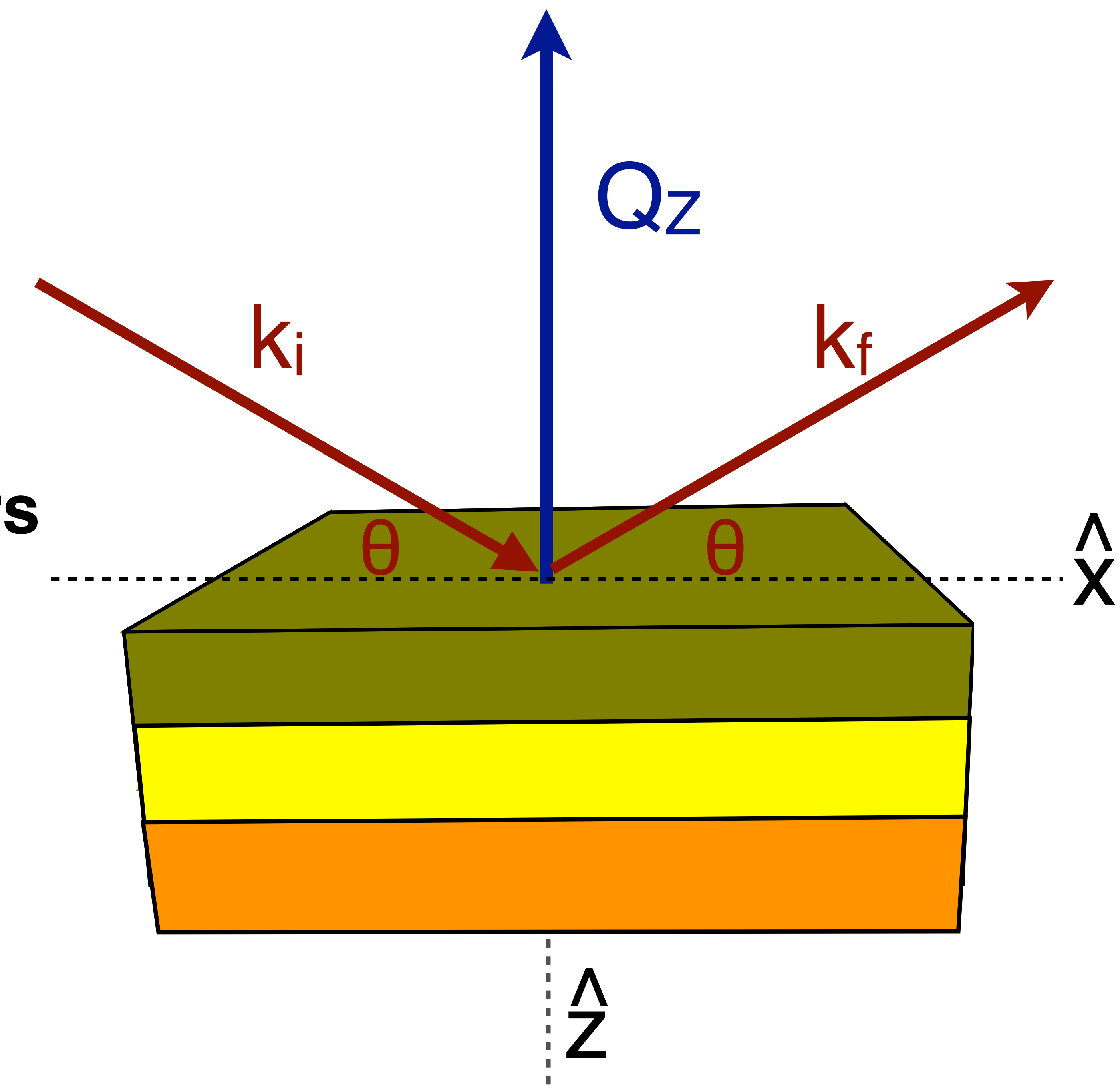

**neutron : nuclei (nuclear) scattering**




**neutron : electron (magnetic) scattering**

# reflectometry:  buried interfaces

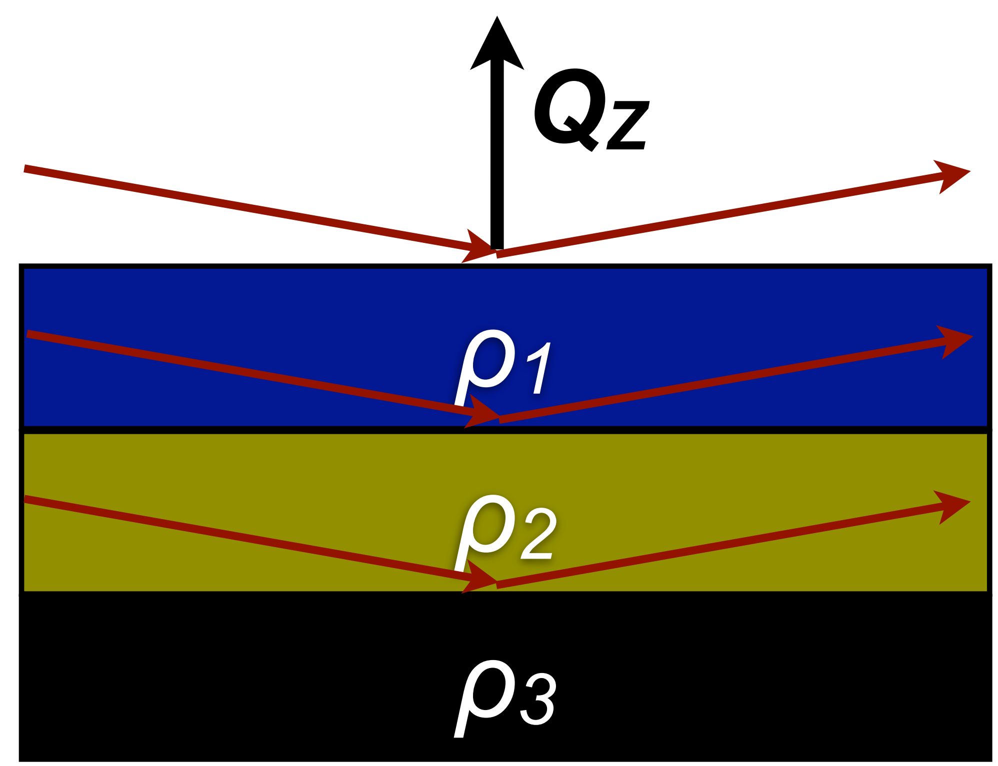
- R(Qz) function only of n(z)
- think of samples as stacks of slabs - a 1-D problem
- **characterize buried layers**
  - nuclear & magnetic depth profiles
  - sub-nm resolution achievable



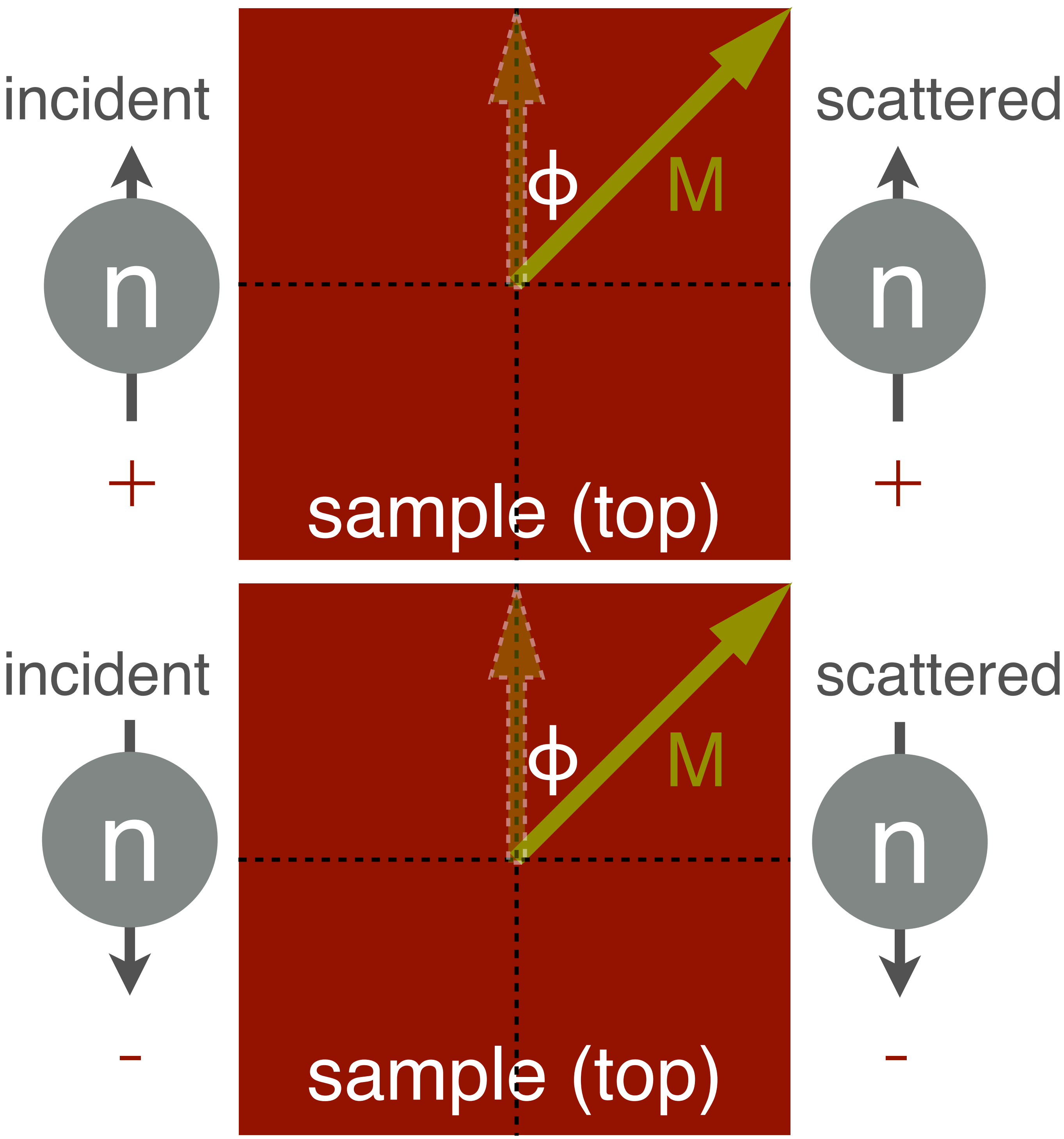
# scattering length density

- neutrons reflect at interfaces of differing $n$
- scattering length density:
- $\rho(z) = (1 - n^2) Q_Z^2 / \pi$

  $= \rho(z)_{nuclear} + \rho(z)_{magnetic}$
- $\rho_{nuclear} = \sum_i N_i b_i$ ,
- $N$ is the number density
- $b$ is the scattering length
- $\rho_{magnetic} = 2.853 \times 10^{-9}\ M$ (kA m$^{-1}$)
- $M$ is the magnetization
- neutron polarization helps differentiate $\rho_{nuclear}$ and $M$ profiles



# polarized beam:  non spin-flip




*Born approximation:*

$$R^{++}(z)$$

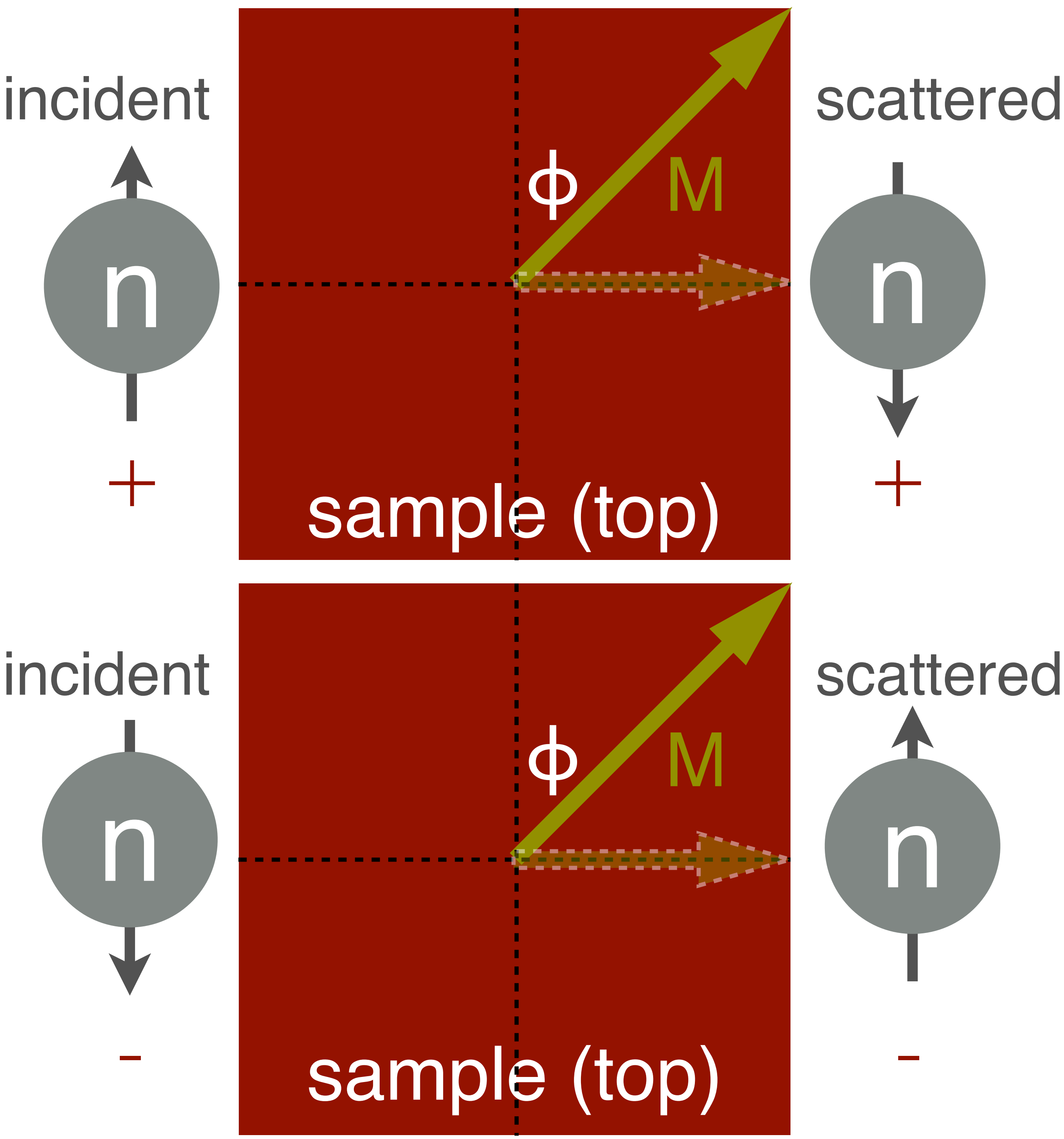
$$\alpha \int |\rho_{nuc} + \rho_{mag} \cos\phi | e^{iQ_z z} dz$$

$$R^{--}(z)$$

$$\alpha \int |\rho_{nuc} - \rho_{mag} \cos\phi | e^{iQ_z z} dz$$

- nuclear profile
- in-plane M profile ll H

# polarized beam:  spin-flip



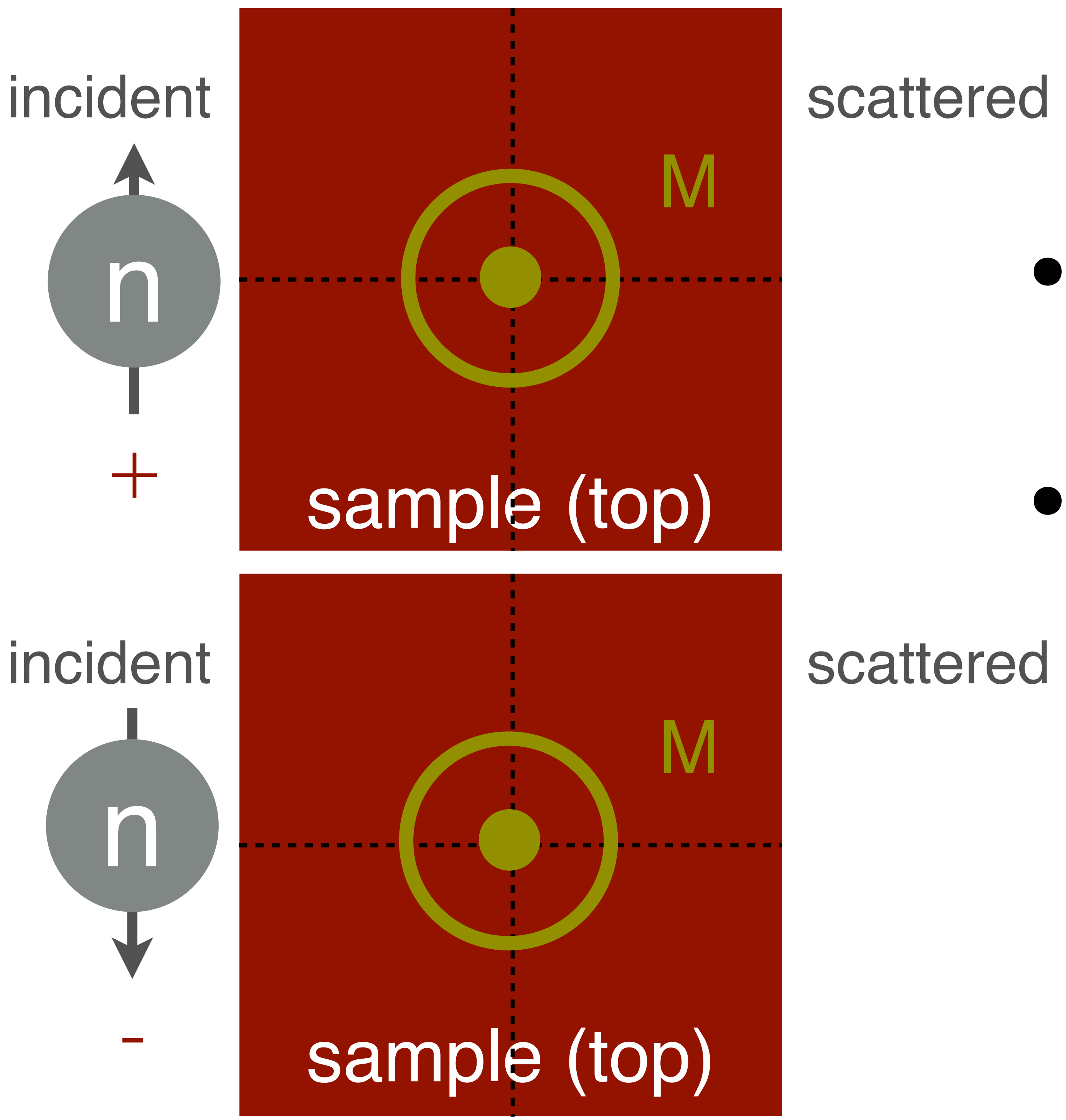

*Born approximation:*

$$R^{+-}(z) = R^{+-}(z)$$

$$\alpha \int |\rho_{mag} \sin\phi| e^{iQ_z z} dz$$

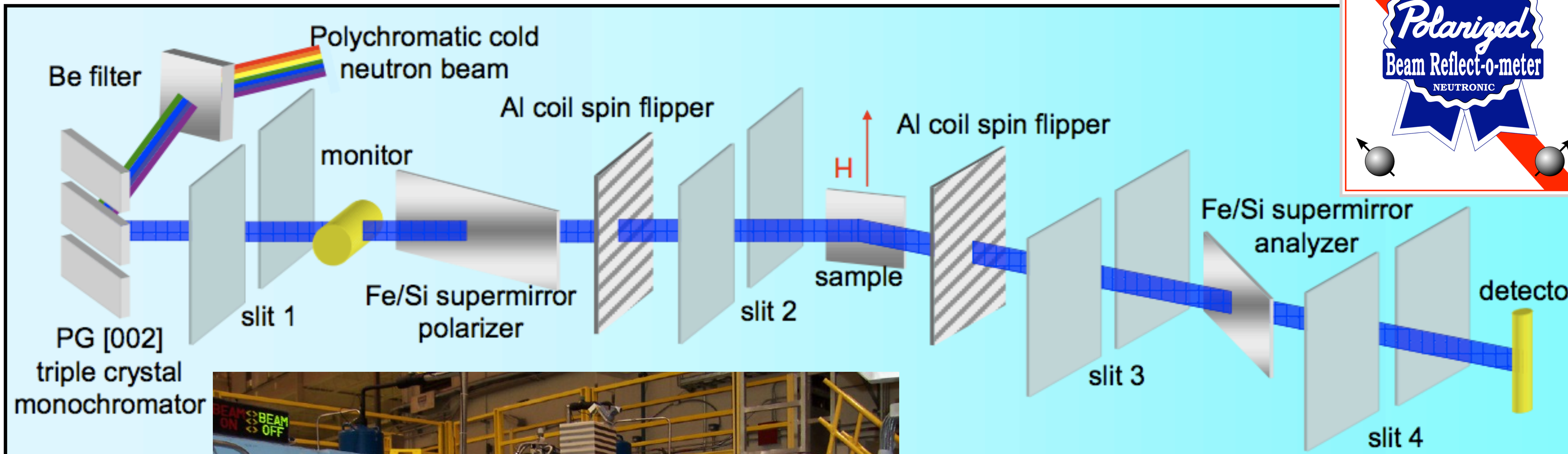
- purely magnetic
- in-plane M profile ⊥ H

# surface normal M?




- M along surface normal does not scatter
- implcations for perpendicular media

# PBR (NG1) at the NCNR




- one of a handful globally
- buried magnetism
- nuclear contrast
- wide variety of science
- also Asterix at LANL